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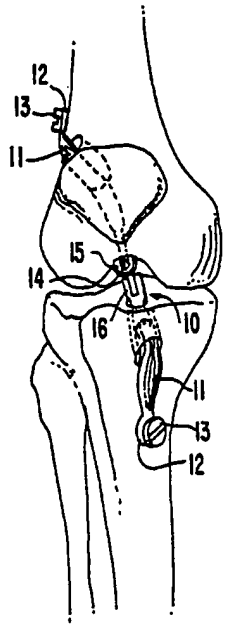
(54) **Mechanical Ligament.**

(57) The present invention relates to a prosthetic ligament comprising at least one intra-osseous bearing (14,15) one member of which is connected to a bone of a joint and an intra-articular linkage means (16) connecting the other member of the intra-osseous bearing to the other bone so that multiple dimensions of motion are provided between the bones.

*FIG. I.*




EP 0 260 787 A1

# MECHANICAL LIGAMENT

This invention relates to a mechanical prosthesis for replacement of a ligament between two bones in the human body. Within the context of this invention, ligaments are defined as bands of fibrous tissue connecting articulate bones.

The primary function of these ligaments is to provide restraints to the movement of one bone relative to another. During body movement, tensile loads are imposed on the ligaments. The rotation of one bone relative to another that occurs with this articulation also causes bending in the ligaments. The loss of or damage to these ligaments leads to abnormal joint movement and disability.

Current ligament prostheses attempt to mimic the natural ligament through the use of flexible materials. These materials possess different physical properties from those of the natural ligament. Failure in these prosthese has often been due to inadequate tensile strength or loss of tensile strength with time. Even if the initial strength of the material is adequate, the physical geometry of the prosthesis dictated by attachment to bone and by joint flexion may lead to failure through fatigue, abrasion, and cutting against bone surfaces.

According to the present invention there is provided a prosthesis for replacing a ligament connecting two adjacent bones of the body comprising at least one bearing capable of being affixed to one bone, and linkage means for connecting said bearing to said other adjacent bone, such that said linkage means and bearing provide multidimensional freedom of movement between said two adjacent bones.

The linkage means may include a second bearing affixed to the other bone. The bearing may be a ball and socket or a hinge. The linkage means may be a chain, a turnbuckle, a rigid linkage means, or strands of a synthetic polymer in a braided, woven or multistranded form. In one embodiment, the prosthesis has two bearings which are balls and sockets and turnbuckle linkage means. In another embodiment, the prosthesis has one bearing which is a ball and socket, the linkage means is a turnbuckle and the second bearing is a clevis-type hinge. The synthetic polymer is preferably expanded porous polytetrafluoroethylene.

Previous proposals have taught the use of prosthetic joints with bearing surfaces to replace a natural joint in the body. Unlike these prior proposals, the present invention involves the use of mechanical elements, that is, a combination of one or more links and bearings to preserve the joint and restore normal movement.

The invention will now be particularly described,by way of example, with reference to the accompanying drawings in which:-

Figure 1 depicts schematically one embodiment of prosthesis according to the invention implanted in a knee joint;

Figure 1a depicts schematically the attachment of the prosthesis of Figure 1 to a bone;

Figure 2 shows a schematic perspective view of one prosthesis constructed in accordance with the present invention;

Figure 2a and 2b are schematic representations of parts of the prosthesis of Figure 2;

Figure 3 shows a schematic perspective view of another prosthesis with chain linkage constructed in accordance with the present invention;

Figure 3a shows schematically the prosthesis of Figure 3 implanted in a knee joint;

Figure 4 shows a schematic perspective view of another prosthesis with turnbuckle linkage constructed in accordance with the present invention;

Figure 5 shows a schematic perspective of yet another prosthesis constructed in accordance with the present invention;

Figure 5a depicts schematically another means of implanting the prosthesis in a knee joint;

Figure 6 shows a schematic perspective view of another prosthesis constructed in accordance with the present invention;

Figure 6a depicts schematically the prosthesis of Figure 6 implanted in a knee joint, and

Figures 7,8,9 and 10 show schematic perspective views of the prosthesis with rigid linkage constructed in accordance with the present invention.

The prosthetic ligament described herein comprises an intra-osseous bearing of which one member of the bearing is connected to one bone of a joint and the other member of the bearing is connected by linkage means to the other bone of the joint, so that multiple degrees of movement are provided between the bones. The linkage means can include a second bearing. The one bearing member can be connected to its associated bone by an intra-osseous connecting member which is built to fit snugly into a surgically prepared bone tunnel that exits near the attachment of the ligament to be replaced. One end of the linkage is connected to the other bearing member and the other end of the linkage member is attached to the associated bone. The linkage means can be connected to the other bone either directly or by a second intra-osseous connecting member implant-

Figure 6 shows another embodiment 60 of the invention. Here the intra-osseous connecting members 61 are frusto-conical shaped and constructed of a biocompatible metal. The intra-osseous members are press fit into the bone tunnel. For this embodiment, it is not necessary to provide for external fixation to the bone.

In this embodiment, one of the intra-osseous members 61 is fitted with a socket 15. The other intra-osseous member is fitted with a hinge 42. The intra-articular linkage means 64 is a polymeric material, preferably expanded polytetrafluoroethylene, which is compressed into a ball 14 at one end and is compressed at the other end to form an eyelet 65. The central region of the connecting member 64 may be braided, woven, or multistranded. The ball 14 is received in the socket 15 of one intra-osseous member and the eyelet 65 fits within the hinge 42 of the other intra-osseous member. This configuration also provides for bone movement in rotational, horizontal and vertical directions.

Figures 7 through 10 show embodiments in which the linkage means comprises a rigid bar. In Figures 7,8 and 9, the intra-osseous bearing members consist of multistranded, porous polymers that have a loop (not shown) at the outer end for bone attachment by a cortical screw. In Figure 7, one end of the first intra-osseous connecting member 11 is shaped to form the ball 14 of a ball and socket bearing 14,15. The intra-articular linkage means is comprised of a rigid bar 71 and the second intra-osseous connecting member 11 is fitted for a clevis hinge 42. The intra-articular linkage means may be constructed of a biocompatible metal. This configuration provides for rotational movement as well as movement in the vertical and horizontal direction.

The prosthesis of Figure 8 is constructed in a manner similar to that of Figure 7 except that both bearing members are clevis hinges. This configuration provides for rotational movement as well as movement in the vertical and horizontal direction.

Figures 9 and 10 depict mechanical ligaments 90,100 in which the bearings are balls and sockets 14,15 and the linkage means is a rigid bar 91. Figure 9 shows an intra-osseous member comprised of multistranded porous polymer. The ligament shown in Figure 9 permits for rotational movement as well as movement in the vertical and horizontal directions.

Figure 10 shows an embodiment in which the intra-osseous members are frusto-conical and are constructed of a biocompatible metal. Here, as described above, the intra-osseous members are press fit into the bone tunnel. This configuration provides for rotational movements as well as movement in the vertical direction.

## Claims

1. A prosthesis for replacing a ligament connecting two adjacent bones of the body comprising at least one bearing capable of being affixed to one bone, and linkage means for connecting said bearing to said other adjacent bone, such that said linkage means and bearing provide multidimensional freedom of movement between said two adjacent bones.

2. A prosthesis according to claim 1 wherein said linkage means includes a second bearing capable of being affixed to said other bone.

3. A prosthesis according to claim 1 wherein said bearing is a ball and socket.

4. A prosthesis according to claim 1 wherein said bearing is a hinge.

5. A prosthesis acording to claim 1 wherein said linkage means is a chain.

6. A prosthesis according to claim 1 wherein said linkage means is a turnbuckle.

7. A prosthesis according to claim 1 wherein said linkage means comprises strands of a synthetic polymer in a braided, woven or multistranded form.

8. A prosthesis according to claim 1 wherein said bearing is of the clevis type.

9. A prosthesis according to claim 2 wherein said bearings are balls and sockets and said linkage means is a turnbuckle.

10. A prosthesis according to claim 2 wherein said bearings are clevises and said linkage means is a turnbuckle.

11. A prosthesis according to claim 2 wherein said one bearing is a ball and socket, said linkage means is a turnbuckle and said second bearing is a clevis.

12. A prosthesis according to claim 7 wherein said synthetic polymer is expanded, porous polytetrafluoroethylene.

13. A prosthesis according to claim 1 wherein said linkage means and bearing provide three dimensional movement.

14. A prosthesis according to claim 2 wherein said bearings are balls and sockets and said linkage means is a rigid bar.

15. A prosthesis according to claim 2 wherein said bearings are clevis hinges and said linkage means is a rigid bar.

16. A prosthesis according to claim 2 wherein one said bearing is a ball and socket and the other is a clevis hinge, and said linkage means is a rigid bar.

ed into the other bone. The prosthesis may be implanted completely assembled and adjusted during surgery or may be assembled, implanted and adjusted during surgery.

The present invention enables the flexible collagenous structures comprising natural ligament which connect bones in a joint to be replaced by a combination of mechanical elements which allow multidimensional bone movement. Bearings are provided in strategic positions of the prosthesis to provide for rotational movement about one or more axes. The linkage means may be either rigid or flexible and, where two bearings are provided, connect the bearings to one another. The use of bearings eliminates fatigue considerations arising from joint motion. The invention provides for use of rigid metallic materials or composite materials that are resistant to abrasion or erosion by bone surfaces. The problem of reduced effective lifetime of synthetic ligaments due to abrasion is thus substantially eliminated.

Figures 1 and 1a depict schematically one embodiment of a three-membered prosthesis according to the invention. The prosthesis 10 is shown in detail in Figure 2. The intra-osseous connecting members 11 each has a ball-shaped bearing member 14 at one end and may be constructed of a multistranded, strong, porous polymer such as expanded, porous polytetrafluoroethylene that allows for tissue ingrowth. The other end of each member 11 is formed into an eyelet 12. Each eyelet may then accept a cortical bone screw 13 as shown in Figure 1a for fixation to a bone outside the joint.

As shown in Figure 2, the intra-articular linkage means 16 comprises a turnbuckle with socket 15 on either end that receive the ball-shaped bearing members 14 of the intra-osseous connecting members 11. The ball and socket hinges and turnbuckle allow for movement both radially and vertically. The turnbuckle allows for adjustment of the length of the prosthesis during surgery.

Figures 2a and 2b show two different embodiments of the bearing portion 14 of the intra-osseous members 11. In Figure 2a the strong, porous polymer strands are compressed and shaped into a small ball 14'. The small ball is further surrounded by a heat treated hard thermoplastic such as polyethylene and further shaped into the ball-shaped bearing member 14.

Figure 2b shows an alternative embodiment wherein a metal socket is attached to the end of the intra-osseous connecting member. The socket may be either a one or two piece member and is capable of holding the compressed end of the intra-osseous connecting member by either a pin or a set screw passing through the compressed end.

Figure 3,3a and 4 show further embodiments of the invention. In Figure 3, the intra-osseous members 11 are similar to those of prosthesis 10 in Figure 2, however, the adjacent ends of these members are each compressed and formed into loop 32 to be connected by means of a chain linkage 31. This prosthesis is attached to the bone joint in a manner similar to that discussed above as shown in Figure 3a. Eyelets 12 are formed at the outer ends of the intra-osseous members 11 and accept a cortical bone screw 13 for fixation outside the joint. The linkage means 31 is a chain and may be comprised of a biocompatible metal such as titanium and polymer such as expanded polytetrafluoroethylene. The linkage means allows for adjustmen of the length of the prosthesis during surgery. This embodiment allows for rotational movement as well as movement in horizontal and vertical directions.

In Figure 4, the linkage means 16 is a turnbuckle. The bearing means comprises a socket 15 located on one end of the linkage means to receive a ball 14 similar to that discussed above. The second bearing means comprises a clevis hinge 42 on the other end of the turnbuckle that is adapted to fit on to an intra-osseous member 11. The clevis hinge 42 is to be contructed of a biocompatible metal which fits snugly within a compressed portion of the expanded, porous polytetrafluoroethylene polymer used in the intra-osseous member 11 and is held in place by a screw 41. The intra-osseous member containing the ball on one end is similar to that described above. The method of implanting and attaching prosthesis 40 to the bone joint is similar to that described above. This configuration also permits bone movement both radially and vertically.

Figure 5 shows another embodiment of the invention. Figure 5a shows the prosthesis 50 implanted in a knee joint. Referring to Figure 5a, intra-osseous connecting members 51 are constructed of titanium or other biocompatible metal and are press fit into the bone tunnels. Screws 52 are provided for immediate external fixation of the prosthesis to the bones. The other ends of the intra-osseous members are shaped into balls 54 which are received by the sockets 53 which are located at each end of the intra-articular linkage means 55. In this illustration, the intra-articular linkage means 55 is a turnbuckle. Alternatively, the intra-osseous connecting means may have sockets fitted at the ends adjacent to the linkage means. The linkage means may have both ends shaped into balls which may be received by the sockets.

FIG. 1.

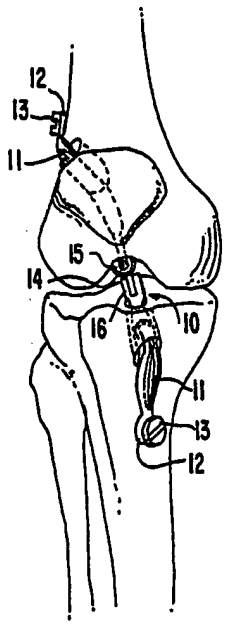



FIG. 1a.

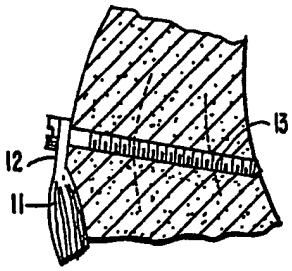



FIG. 2.

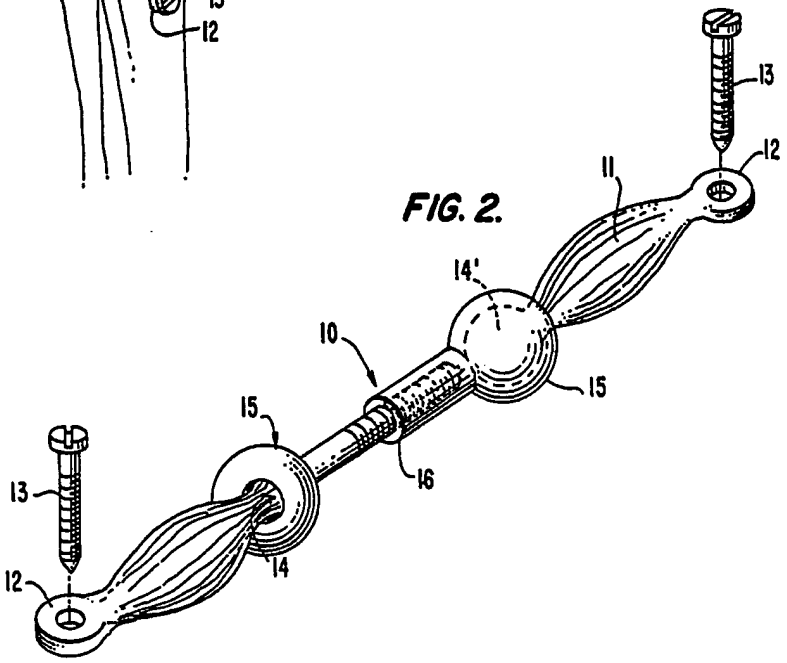


FIG. 1.

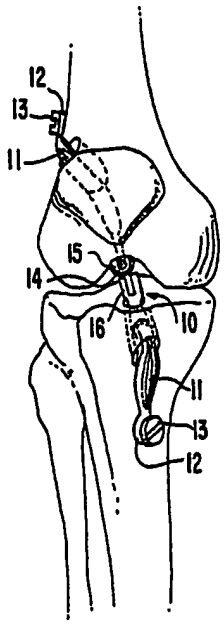



FIG. 1a.

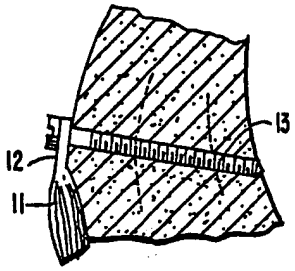



FIG. 2.

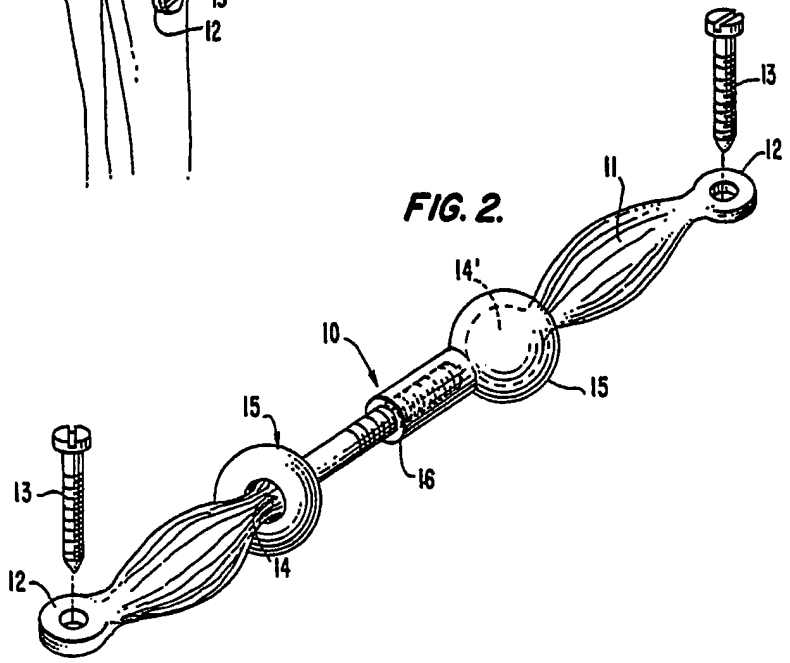


FIG. 4.

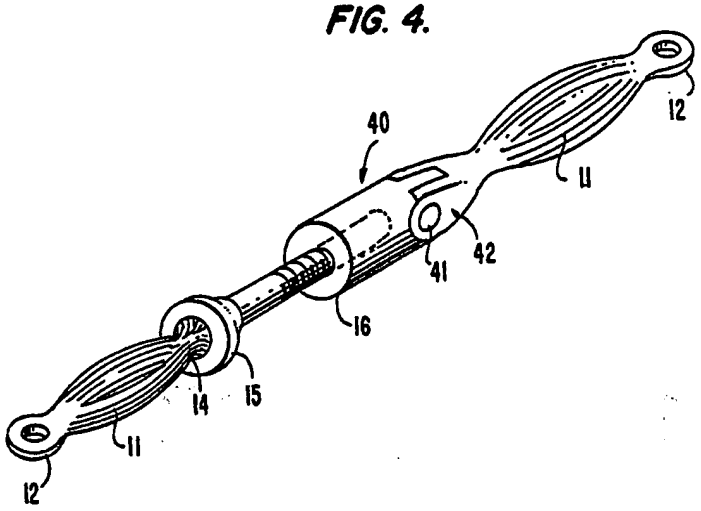



FIG. 5a.

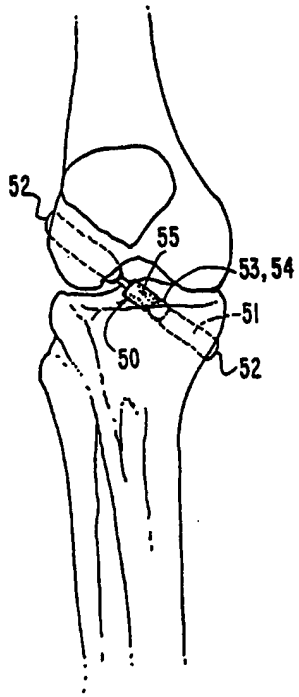
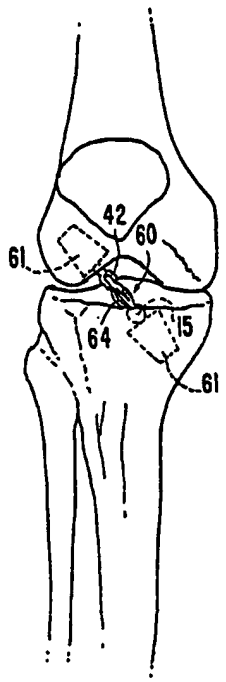



FIG. 6a.



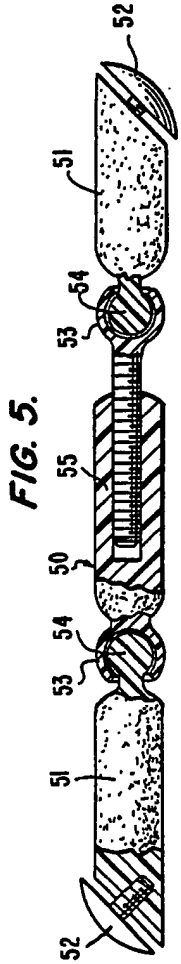



FIG. 5.

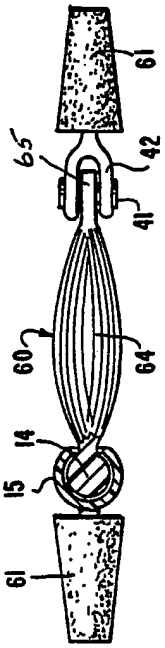



FIG. 6.

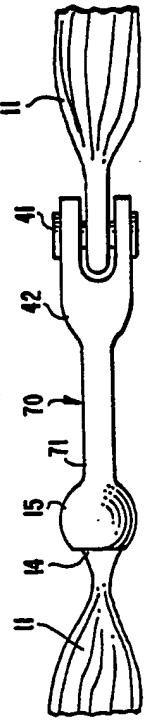



FIG. 7.

FIG. 8.

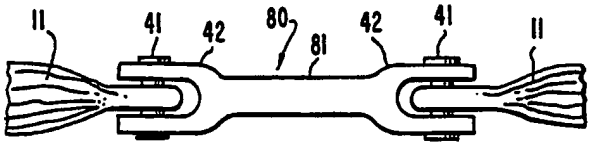



FIG. 9.

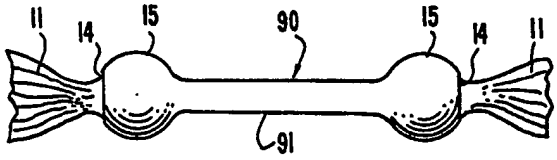
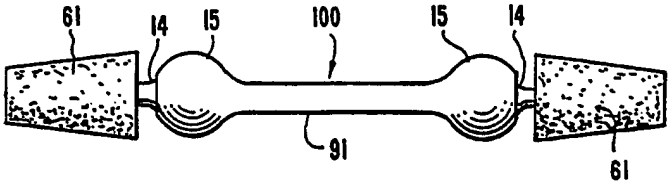



FIG. 10.



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# EUROPEAN SEARCH REPORT

Application Number

EP 87 30 5697

## DOCUMENTS CONSIDERED TO BE RELEVANT

| Category | Citation of document with indication, where appropriate, of relevant passages | Relevant to claim | CLASSIFICATION OF THE APPLICATION (Int. Cl.4) |
|---|---|---|---|
| X | US-A-3 988 783 (TREACE)<br>* claims 1, 7; figures 3-7 * | 1 | A 61 F 2/08 |
| A | * claim 2 * | 2 | |
| A | US-A-3 953 896 (TREACE)<br>* figures 1-4; column 1, lines 56-68 * | 1 | |
| A | GB-A-2 039 220 (QUEEN'S UNIVERSITY)<br>* claim 1; page 3, lines 70-82 * | 1 | |
| A | EP-A-0 106 501 (W.L. GORE & ASSOCIATES, INC.)<br>* claim 1 page 2, lines 1-17; figure 8 * | 1,7,12 | |

TECHNICAL FIELDS SEARCHED (Int. Cl.4)

A 61 F 2/00

The present search report has been drawn up for all claims

| Place of search | Date of completion of the search | Examiner |
|---|---|---|
| BERLIN | 22-10-1987 | KANAL P K |

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